

# **LINERS AND LOW LUMINOSITY AGN IN THE ROSAT DATABASE**

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This program has led to a series of papers being written and published in the Astrophysical Journal. Together these papers try to explain major parts of the LINER and low luminosity AGN puzzle.

One paper ("Accretion Disk Instabilities, Cold Dark Matter Models, and Their Role in Quasar Evolution", Hatziminaoglou E., Siemiginowska A., & Elvis M., 2001, ApJ, 547, 90) describes an analytical model for the evolution of the quasar luminosity function. By combining the Press-Schechter formalism for the masses of initial structures with the luminosity distribution for a population of single mass black holes given by an unstable accretion disk an almost complete end-to-end physics-based model of quasar evolution is produced. In this model black holes spend 75% of their time in a low accretion state (at  $10^{-4} L_{\text{Edd}}$ ). This low state population of black holes is likely to be observed as the LINER and low luminosity AGNs in the local universe.

Another paper ("Broad Emission Line Regions in AGN: the Link with the Accretion Power", Nicastro F., 2000, ApJ Letters, 530, L65) gives a physical basis for why low state black holes appear as LINERS. By linking the Lightman-Eardley instability in an accretion disk to the origin of a wind that contains the broad emission line cloud material this model explains the large widths seen in these lines as being the Keplerian velocity of the disk at the instability radius. For LINERS the key is that below an accretion rate of  $10^{-3} M_{\text{Edd}}$  the Lightman-Eardley instability falls within the innermost stable orbit of the disk, and so leaves the entire disk stable. No wind occurs, and so no broad emission lines are seen. Most LINERS are likely to be black holes in this low state. Tests of this model are being considered.

In another paper we investigated the origin of the absorption in low luminosity AGN ("Ubiquitous Variability of X-ray Absorbing Column Densities in Seyfert 2 Galaxies", G. Risaliti, M. Elvis and F. Nicastro 2002, ApJ, 571, 234) we find results that seem to contradict the current model of a donut-shaped torus several light years from the active nucleus. Rapid changes in absorption imply a much smaller region doing the absorbing. We suggest the apparently paradoxical explanation that these source have weak broad emission lines because they have too much broad emission line gas, so much that it self-obscures. In the context of a wind model for quasars and AGN (Elvis 2000), this can naturally explain the otherwise puzzling low dust-to-gas ratio in AGN.

Our proposed BLR origin for seiyfert obscuration predicts much shorter timescale changes in NH. We will investigate this by means of the RXTE ASM data, in which we should find occasional 'flares' due to the parting of the clouds; and in long observation with ROSAT, RXTE BeppoSAX and ASCA to search for similar, smaller, events.

We have used long Beppo-SAX observations of NGC4151 to investigate short term changes in the absorption toward this AGN. We find 2 events that show this signature, and they occur on a timescale of 1/2-day, some 100 times faster than any previous reported NH changes (Puccetti et al. in preparation). This drives up the density of the absorbing gas to high levels, and greatly strengthens the argument we made earlier (Risalit et al. 2002) that the absorbers lie close in to the nucleus.

In order to catch short term flares due to a parting of the clouds in Seyfert 2s we have initiated a study of RXTE ASM data for a sample of about 20 objects. We see high probability flares in several objects at about the frequency predicted

from the variations seen in Risaliti et al. We are now performing extra tests to be sure of the validity of these low signal-to-noise flares.

We used an ASM signal of such a flare to trigger a preapproved Chandra TOO of NGC4388, normally a very heavily obscured AGN. Our Chandra grating spectrum still showed a large column density, but at a value well below previous measurements. Since the TOO response time was 2 days, and the flares last only about 1 day, it is likely we caught NGC4388 in the process of closing up the gap in its cloud structure. The Chandra gratings spectrum serendipitously provides a good spectrum of the optically thin, line emitting, gas around the nucleus of NGC4388, which we will write up separately.

We believe that this program has made a strong, even dramatic, contribution to our understanding of low luminosity AGN.

Talks on the papers above were given at several meetings:

"Large Scale Structure in the X-ray Universe" (Santorini, Greece Sept 1999);

"Observational & Theoretical Progress in the Study of Narrow-Line Seyfert 1 Galaxies", Bad Honnef, Germany, Dec 8-11 1999;

"New England Regional Quasar Meeting" (Brandeis U. Mass, May 2000);

"Issues in Unification of Active Galactic Nuclei", ASP Conference Proceedings, Vol. 258. Edited by Roberto Maiolino, Alessandro Marconi, and Neil Nagar.

"Mass Outflow in Active Galactic Nuclei: New Perspectives", ASP Conference Proceedings, Vol. 255. Edited by D. M. Crenshaw, S.B. Kraemer, and I. M. George.

"American Astronomical Society Meeting 197" (2000)

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Chandra AO2 proposals were written and accepted to study low luminosity AGN, one radio-quiet, one radio-loud.

A Chandra AO3 TOO program was approved, half of which was to study a low luminosity AGN in outburst.

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